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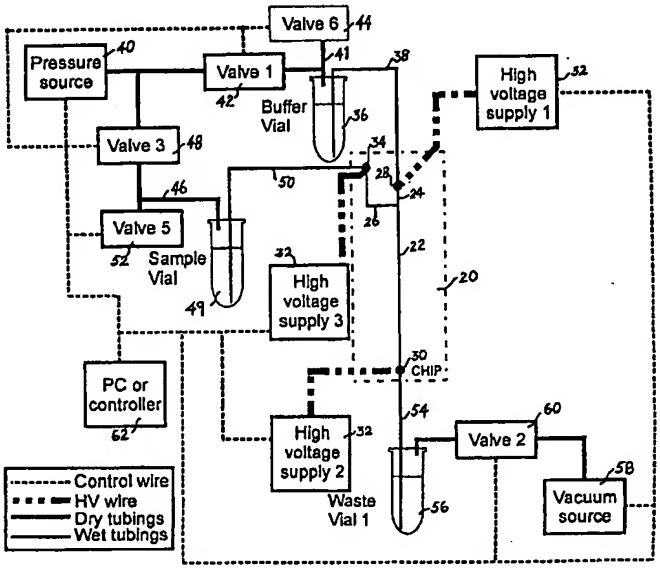

(57) Abstract

A dispensing system for various applications such as electrophoresis is disclosed. For electrophoresis, the electrophoretic module includes an electrophoretic chip (20) having a plurality of electrophoretic channels (22) each connected to a sample reservoir (26) and a buffer reservoir (24). At the heart of the system is an automated loading system for the parallel loading of multiple channels. The system is further equipped with a power source (32), electrically connected to the channels, for electrophoresis of the samples therein. A controller (62), connected to each element, is provided to control the loading and electrophoresis operations. The system allows for fully automated, high performance and high throughput electrophoresis.

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HIGH PERFORMANCE DISPENSING APPARATUS

FIELD OF THE INVENTION

The present invention is related to separation technology. In particular, the present invention is related to high performance capillary electrophoresis, chromatography and extraction.

BACKGROUND OF THE INVENTION

In chemical and biological research and routine analysis, a large number of samples need to be analyzed at the same time and under similar conditions. Since microfabricated capillary electrophoresis (CE) chips were introduced in 1992 (J. Chromatogr. 1992, 593, 253-258) Many experiments have been done on them and results have shown that these devices can increase the speed of CE separation by an order of magnitude.

In some previous experiments with CE chips (J. Chromatogr. 1992, 593, 253-258; Anal. Chem. 1992, 64, 1926-1932; Anal. Chem 1994, 66, 3472-3476; Proc. Natl. Acad. Sci. USA 1994, 91, 11348-11352) and capillary array electrophoresis chip (CAE) chips (Anal. Chem, 1997, 69, 2181-2186), plastic pipet tips was pushed into sample holes or tubing glued to the substrate to form reservoirs along with manual electrical contacts. These systems, however, are impractical for large numbers of samples.

To simplify sample handling and electrode introduction, and to increase the volume of buffer in the cathode and anode reservoirs, an elastomer (Sylgard 184, Dow Corning) reservoir array and electrode array were developed. (Proc. Natl. Acad. Sci. USA 1998, 95, 2256-2261). However, almost all steps in these experiments were performed manually, including loading of materials in reservoirs and channels, washing and flushing. Such manual operations is not only time-consuming but also error prone. Furthermore, they are not conducive for handling large numbers of samples.

With the development of CAE on chips, the possibility of analyzing multiple samples in parallel moves one step closer to reality. However, numerous problems remain to be solved, including multi-sample loading, injection and electrophoresis. Furthermore, the system needs to be washed and flushed effectively after use. Similarly, for microfabricated liquid chromatography system, effective methods for sample and mobile phase introduction are required. In addition it is often necessary to perform sample preparation or extraction prior to chromatography or electrophoretic separation. In particular, for samples which are available only in minute quantity, a microscale liquid dispensing system is required to prevent sample loss during sample preparation and extraction.

OBJECT OF THE INVENTION

It is therefore an object of the present invention to provide a dispensing or loading system to overcome the shortcomings as stated above.

It is another object to provide as high performance capillary electrophoresis system which can handle a plurality of samples.

It is another object to provide a capillary array electrophoretic system which can perform parallel loading of multiple buffers and samples.

It is a further object to provide a dispensing system embodiment which may be adapted for microscale liquid chromatography.

It is a further object to provide a dispensing system embodiment which may be adapted for microscale sample preparation and extraction.

SUMMARY OF THE INVENTION

The above objects are generally accomplished by providing an automatic loading or dispensing system for various applications, for example separation techiques such as chromatography and electrophoresis, and biochemical and biological reactions. For electrophoresis, the electrophoretic system includes an electrophoretic chip having a plurality of electrophoretic channels each connected to a sample reservoir and a buffer reservoir. At the heart of the system is an automated loading system for the parallel loading of multiple channels. The system is further equipped with a power source, electrically

connected to the channels, for electrophoresis of the samples therein. A controller, connected to each element, is provided to control the loading and electrophoresis operations.

In the preferred embodiment the loading system comprises a buffer loading module and a sample loading module, which may have similar structures and functions. The buffer loading module, connecting at least one buffer container to each of the buffer reservoirs by channel connecting means, is provided for the parallel loading of multiple buffer reservoirs and channels. The sample loading module, connecting the sample vials to the sample reservoirs, is provided for sample loading. In another embodiment, a single loading module is provided for loading both the buffer and the sample. This is accomplished by a switch in the connection, in which the loading module is first connected to the buffer reservoir such that buffer loading can occur, followed by switching over of the channel connecting means to the sample reservoir and replacement of the buffer vials with sample vials, such that sample loading can occur.

In the most preferred embodiment, the loading module is deployed with a pneumatic system of interconnecting fluid conduits to supply simultaneously the forces required to load multiple reservoirs/channels. In order to allow different receptacles (e.g. reservoirs or channels) to be loaded with different liquids, tubings are provided to directly connect the liquids to the corresponding receptacle. When the fluid pressure is switched on, the different liquids would be loaded simultaneously.

The power source may be a plurality of high voltage power supply with one or more output outlets for maintaining voltage differences between at least two points. The power supply is connected to the two ends of each channel for maintaining a voltage difference required for electrophoresis of samples along the channels. In the preferred embodiment, a third electrical connection is provided in the sample reservoir to prevent a continuous leaching of samples during electrophoresis.

Other optional features include a vacuum source, connected to a buffer waste container, which is used to facilitate the removal of excess buffer during loading, and the removal of washing fluid during the washing and rinsing cycles. The vacuum source may also be connected to another optional sample waste container to facilitate the removal of excess sample.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1A is a system diagram of one modular electrophoretic system according to the present invention.

Figure 1B is the top plan view of an electrophoretic module of the same system according to the present invention.

Figure 1C is the longitudinal cross-sectional view along a channel of a capillary chip of an electrophoretic module of the same embodiment.

Figure 1D is the bottom plan view of the loading end interface of the same embodiment.

Figure 1E is the bottom plan view of the running end interface of the same embodiment.

Figure 1F is the cross sectional view of part of the buffer loading module of the same embodiment.

Figure 1G is the cross sectional view of a waste collector module of the same embodiment.

Figure 2A is a system diagram for a second embodiment according to the present invention.

Figure 2B is a top plan view of an electrophoretic module according to the second embodiment.

Figure 2C is the longitudinal cross-sectional view along a channel of a capillary chip of an electrophoretic module of the second embodiment.

Figure 2D is the bottom plan view of the loading end interface structure of the second embodiment.

Figure 3 is the system diagram for a third embodiment according to the present invention.

DESCRIPTION OF THE INVENTION

In the following description, numerous specific details are set forth such as the specific connections between the various module, in order to provide a thorough understanding of the present invention. In other instances, well known elements such as pressure and vacuum pumps, power supply and pneumatic valves are not described in detail in order not to unnecessarily obscure the present invention.

Figure 1A is a diagrammatic illustration of the various modules of the and how they are connected to each other according to one embodiment of the present invention. At the center is the capillary array chip **20** with a plurality of electrophoretic channels **22**. Each channel has a loading end **28** and a running end **30**, with a buffer reservoir **24** and a sample reservoir **26** connected to the loading end. For ease of illustration, only one channel and corresponding reservoirs are shown in these figures. It should be understood that a CAE chip may contain numerous channels, and the following description to one channel and its corresponding reservoirs apply to all other channels as well.

Electrical connections are provided at the two ends (loading end **28** and running end **30**) of each channel, allowing the channel to be connected to a power source **32** which may include several high voltage power supplies. Another optional electrical connection can be made between the running end **30** and the sample reservoir at point **34** for initial sample injection into the channel. During electrophoresis, the voltage at point **34** is set slightly higher than the voltage at point **28** to prevent leaching of the sample continuously into the channel.

The loading of buffer in the buffer vial **36** into the buffer reservoir **24** is performed by the buffer loading module. In this embodiment, a pneumatic system is employed to force the liquid buffer through tubing **38** into reservoir **24**. Pressure source **40** is connected to the buffer vial via fluid conduits **41**, and provides the fluid pressure, which is controlled by valve **42**. The fluid pressure source may be a conventional air pump with a preset air pressure and flow rate. The flow rate used depends on the number and size of the channels and connecting tubings, and may be determined without undue experimentation. Residual pressure after loading is released by opening release valve **44**. Only one buffer container or vial is shown in Figure 1A for ease of illustration. It should be understood that numerous buffer vials each connected by a separate tubing to a different channel may be provided. Furthermore, through air-tightly interconnected fluid conduits **41**, a plurality of different buffers in different buffer vials can be loaded into different buffer reservoirs as described in a later section.

Pressure source **40** is also connected via a second series of interconnected fluid conduit **46** to a series of sample vials **49** (only one shown in Figure 1A). Operating under the same principle as the buffer loading module, an air-tight system allows fluid pressure, controlled by valve **48**, to force liquid samples from sample vial **49** into the corresponding sample reservoir **26** via tubing **50**. Release valve **52** is opened after loading is complete to release any residual pressure within fluid conduit **46**.

The running end **30** of the electrophoretic channel is also connected via tubing **54** to buffer waste container **56**. In this embodiment, buffer waste container **56** is further connected to a vacuum source **58**. When control valve **60** is opened, the suction generated from vacuum source **58** sucks excess liquid in the channel into buffer waste container **56**. This feature is particularly useful for more viscous buffers, but is optional for non-viscous buffers. In such cases, the excess buffers can passively drain into buffer waste container **56**.

The entire electrophoretic system may be controlled by a computer or processor **62** for precision loading and electrophoresis.

Figures 1B and C show in greater detail the electrophoretic module. A chip tray **66** holds an array chip **20** with channels **22** etched into it. A upper plate **70** is bonded together with the bottom plate **71** to form the array chip such that the individual channels are isolated from each other to prevent seeping and mixing of liquid. A loading end interface structure **72** and a running end interface structure **74** are provided to allow

connection to the other modules. Sample reservoir **26** and buffer reservoir **24**, located below the loading end interface structure, are shown as dotted lines in Fig. 1B. Pneumatic interface **76** with an elastomeric sealant **78** provides an air-tight connection to the buffer reservoir **24** via buffer access holes **68** and tubings **38**. The tubings may be made of silica, silicone or plastic materials or any other chemically inert material. The sample reservoir is also connected in an air-tight manner to tubing **50** via sample access hole **67** using a second elastomeric sealant **79** (Tubing 50 is shown in Fig. 1C as the vertical double dotted lines as it falls in front of the plane of the cross-section). Running end interface structure **74** includes pneumatic interface **80** with elastomeric sealant **82** providing an air-tight connection to the running end of channel **22**, which is in turn connected to waste vial **56** via tubing **54** and waste access hole **69**.

Figures 1D and E shows the underside of the loading end and running end interface structures respectively in this embodiment. High voltage interfaces **84** and **86** are also provided for electrical connection between the two ends of the channel for electrophoresis. In this example, each end of each channel is provided with three electrical contacts **88**. At high voltage interface 86 as shown in Fig. 1E, two of the electrical contacts are optional and may be used for conductivity detection after separation of the samples by electrophoresis, while the third electrical contact is meant for the running voltage. For high voltage interface 84 as shown in Fig. 1D, all three electrical contacts may be connected to the high voltage power source, with one connection used to deliver voltage for separation at the electrophoretic channels and other one or two connections to maintain a

voltage for the sample reservoir. Fig. 1D and E also show one embodiment of the elastomeric sealants **78**, in which rectangular sheets of silicone are used to provide an air-tight seal for the entire row of buffer access holes **68** or sample access holes **67**. In the same manner, elastomeric sealant **82** seals off the entire set of waste access holes **69**. Silicone sheets such as Sylgard 184 by Dow Corning may be used.

Figure 1F shows part the buffer loading module, with rack **90** acting as a vial holding means for receiving and securing the vials of buffer solution. The vials of buffer **36** are attached to rack **90** via elastomeric gaskets **92** which gives an air-tight seal along the rim of each vial. Fluid conduit **41** as shown in this embodiment comprises manifold-like fluid channels which interconnect all the buffer vials to the pressure source **40**, and control valves **42** and **44**. Tubing **38** is provided as channel connecting means to connects the content of buffer vials **36** to buffer reservoir **24**. The sample loading module (not shown) is very similar to the buffer loading module, and operates under the same pneumatic principles. The fluid from the pressure source may be any non-reactive gas, such as compressed purified air or nitrogen.

Fig. 1G shows one embodiment of a waste collector module according to the present invention. In this example, multiple tubings **54** connected to the running end of the electrophoretic channels are drained into waste vials **56**. Fluid conduits **96** are connected to vacuum source **58** to facilitate the removal of waste buffers or wash buffer.

In operation, buffer vials and sample vials are connected to the buffer and sample loading modules respectively. Valve **42** is opened to allow air pressure to build up within the fluid conduit **41** of the buffer loading module, which results in buffer being forced via tubing **38** into buffer reservoir **24** and channel **22**. At the same time, valve **60** may be opened to facilitate the removal of air inside the channels, such that no air bubbles would be trapped in the system. After buffer has been loaded, valves **42** and **60** are closed and valve **44** opened to release any residual pressure within fluid conduit **41**. Then valve **48** is opened and pressurized air increases the fluid pressure inside fluid conduit **46**, forcing liquid samples from sample vial **49** into sample reservoir **26** via tubing **50**. Once sample loading is complete, valve **52** is closed and valve **48** opened to allow the release of residual air pressure. To perform the electrophoretic separation, the power supply **32** is switched on, and a sample injection voltage generated at the electrical connection between the loading end **28** and the running end of the channel **30**. A portion of the sample migrates into the channel in the presence of the electrical potential. To prevent further leaching of the sample, a voltage higher than that at point **28** is generated at point **34**. For conductivity or electrochemical measurements, the appropriate electric connections **88** are set up beside the high voltage interfaces **84** and **86**. After electrophoresis and analysis, the system may be washed by replacing the sample and buffer vials with cleaning solutions, and opening the appropriate valves to flush the system. To remove all cleaning solution, air or other drying gas may be flushed through the system.

Figure 2A shows a second embodiment of the present invention in which an additional outlet is provided in the sample reservoir in order to facilitate sample loading. All other elements of the system remain the same as the first embodiment. Sample reservoir **100** is subdivided into inlet reservoir **130** and outlet reservoir **134**. Inlet reservoir **130** functions in the identical manner as in the previous embodiment while outlet reservoir **134** has an additional connection via tubing **106** to a sample waste vial **108**. Sample waste vial **108** may in turn to be connected vial fluid conduits **110** to the vacuum source **112** and controlled by valve **114**. Pressure source **160** is connected to the sample vial **162** via fluid conduit **164** which is controlled by valves **166** and **168**. Sample vial **162** is connected to the sample inlet reservoir via tubing **170**. Buffer in buffer vial **174** is connected to buffer reservoir **126** via tubing **176**.

Figure 2B and C show in greater detail the arrangement of the electrophoretic module. The chip tray **116** and the array chip **118** with its electrophoretic channels **120** are the same as that of the previous embodiment. The running end pneumatic and high voltage interfaces **122** and **124** respectively also remains unchanged. However, besides the buffer reservoirs **126** and the buffer access holes **128**, the sample reservoir is provided with a sample inlet reservoir **130** and a sample outlet reservoir **134**. The loading end pneumatic interface **138** is further provided with an inlet access hole **132** and an outlet access hole **136**. Tubings 170 and 106 form air-tight connections with sample access holes 132 and 136 respectively. As they are not located along the cross-sectional plane, their positions are shown in dotted lines in Figure 1C.

Figure 2D shows the bottom view of the loading end pneumatic and high voltage interfaces **138** and **140** respectively. As in the previous embodiment, a sheet of elastomeric sealant **142** is provided such that the row of sample access holes are airtight to the environment. Similar sealants **144** and **146** are used to isolate the rows of inlet access holes and outlet access holes respectively from the environment. In this way, the entire system is rendered airtight. The running end interface remains the same as the previous embodiment. The dotted lines show the orientation of the buffer reservoir, the sample inlet reservoir, the sample outlet reservoir and the electrophoretic channel for ease of understanding.

The operations of the second embodiment is the same as the first, except that the samples have an escape route at the sample outlet reservoir **134** via the outlet access hole **136.** During sample loading, valve **166** is opened such that the air pressure from pressure source **160** forces samples from sample vial **162** into sample inlet reservoir **130**. At the same time, valve **172** connected to vacuum source **112** may also be opened. As sample inlet reservoir **130** is connected to the sample outlet reservoir **134** sample is loaded into the sample reservoir, and any air originally present would be removed via tubing **106**. As a result, air bubbles are less likely to be trapped in the system. Furthermore, this additional feature also improves the washing process, particularly of the sample reservoir, after electrophoresis.

Figure 3 shows a third embodiment of the present invention, in which one of the loading modules have been removed compared to the first embodiment. In this case, only one inlet control valve **180**, one outlet

control valve **182**, and one fluid conduit **184** are provided. In this case, one vial holding rack (not shown) would have to act as the receiving means for both the buffer vials and the sample vials (both shown as reference numeral **184** for ease of illustration) sequentially as they are loaded. This may be done by first attaching buffer vials to the vial holding rack, and connecting tubing **186** to the buffer reservoir **188**. Then buffer loading may be initiate by opening valve **180**. In this embodiment, valve **192** may also be optionally opened to facilitate buffer loading, with or without vacuum source **194** activated. After buffer loading is complete, excess buffer in the tubing is removed, valve **180** closed, and tubing **186** switched either manually or automatically, to connect to sample reservoir **190**. This is followed by the replacement of the buffer vials with the sample vials. Then valve **180** is opened again to load the samples from the sample vials to the sample reservoir. Electrophoresis will then proceed according to the standard protocols.

While the present invention has been described particularly with references to Figs 1 to 3 with emphasis on an automated loading or dispensing system for capillary electrophoresis, it should be understood that the figures are for illustration only and should not be taken as limitation on the invention. In addition it is clear that the method and apparatus of the present invention has utility in many applications where parallel loading of multiple samples is required. It is clear that the features of the various embodiments may be combined to form additional embodiments. It is contemplated that many changes, combinations and

modifications may be made by one of ordinary skill in the art without departing from the spirit and the scope of the invention described.

For example, it would be clear that other configurations of the sealing sheet or other sealing means may be used to render the system air-tight, e.g. a single larger sheet of silicone may be used to seal both the row of sample access holes and buffer access holes. As the pneumatic means is preferably detachable to facilitate cleaning, a single larger sheet improves the ease of operations.

A similar configuration may be used for the dispensing of liquid in other applications, such as for micro-solid phase extraction and liquid chromatography. In these applications, the electrophoretic channels described in Figures 1-3 would be replaced by columns. The tubings which connect the buffers or samples to the channels would be connected to the columns instead. Additional applications of the loading system include liquid dispensing for microwells and microtiter plates, in which case the channels would be replaced by wells and the tubings leading directly into the wells. It is clear that although buffer and aqueous samples are the examples of liquids to be dispensed, other liquids, such as solvents and salt solutions are equivalents, and are intended to be covered by the scope of the claims.

The vial holding rack for buffers may be adapted to receive a single or small number of containers of buffers, if the running buffers of the various channels are the same. This can be easily accomplished by modifying the holding rack such that the end of the fluid conduit is wide enough to

accommodate a larger-mouthed container, and at the same time allow buffer tubings connected to different electrophoretic channels to be submerged inside the buffer in the larger buffer container. A suitable sealing gasket may be used to ensure that they system is air-tight.

Release valves **44**, **52**, and **182** are useful for the quick release of residual pressure inside the system. However, a low-cost system without these release valves may also function, albeit with a lag time for the residual air pressure to escape.

CLAIMS

1. An electrophoretic apparatus comprising:

an electrophoretic chip containing a plurality of electrophoretic channels each connected to a sample reservoir and a buffer reservoir;

a buffer loading module, adapted to receive at least one buffer container with buffer and connected to said buffer reservoirs, for simultaneous loading of said buffer into said buffer reservoirs and channels;

a sample loading module, adapted to receive sample vials with samples and connected to said sample reservoirs, for simultaneous loading of said samples into said sample reservoirs.

a power source, electrically connected to said channels, for supplying electrical energy for electrophoresis of molecules in said channels; and

controlling means, coupled to said buffer loading module, sample loading module and power source, for controlling the loading and electrophoresis processes.

2. An electrophoretic apparatus comprising:

an electrophoretic chip containing a plurality of electrophoretic channels each connected to a sample reservoir and a buffer reservoir;

a loading module including

vial holding means for receiving and securing a plurality of vials with liquids;

a plurality of tubings each having a first end and a second end, each of said first end dipped inside the liquid in one of said vials, each of said second end connected to a corresponding buffer reservoir; said second end further switchable for connection to a corresponding sample reservoir;

pneumatic means, air-tightly connecting said vials to a common fluid pressure source via interconnecting conduits, for loading said liquid into said buffer reservoir or said sample reservoir;

power source, electrically connected to said channels, for supplying electrical energy for electrophoresis of molecules in said channels;

controlling means, coupled to said loading module and power source, for controlling the loading and electrophoresis process.

3. A method for electrophoresis comprising :

simultaneously loading buffer solutions into a plurality of buffer reservoirs and electrophoretic channels in a capillary array chip;

simultaneously loading samples into a plurality of sample reservoirs in said capillary array chip; and

simultaneously separating said samples in an electrophoretic process.

4. An electrophoretic apparatus according to claim 1 wherein said sample loading module further comprises

a fluid pressure source;

vial holding means adapted to receive a plurality of sample vials containing samples in an air-tight manner;

connecting means for separately connecting each of said sample reservoirs to the sample in a corresponding sample vial; and

pneumatic means for air-tightly connecting said sample in said sample vials to said fluid pressure source, said pneumatic means having interconnecting conduits for forcing said samples into a corresponding sample reservoir;

said buffer loading module further comprises :

buffer holding means adapted to receive at least one buffer container in an air-tight manner;

buffer connecting means for connecting each of said buffer reservoirs to the buffer in said buffer container; and

buffer pneumatic means for air-tightly connecting said buffer container to said fluid pressure source, said buffer pneumatic means having a second set of interconnecting conduits, for forcing said buffer into a corresponding sample reservoir.

5. An electrophoretic apparatus according to claim 1 wherein said electrophoretic channels each has a loading end and a running end,

said sample reservoirs and buffer reservoirs connected to said loading end; said apparatus further comprising a buffer disposal module, connected air-tightly to said running end of said channels, for draining excess buffer from said channel.

6. An electrophoretic apparatus according to claim 2 wherein said electrophoretic channels each has a loading end and a running end, said sample reservoirs and buffer reservoirs connected to said loading end; said apparatus further comprising a buffer disposal module, connected air-tightly to said running end of said channels, for draining excess buffer from said channel.

7. An electrophoretic apparatus according to claim 1 wherein said electrophoretic channels each has a loading end and a running end, said sample reservoirs and buffer reservoirs connected to said loading end; said electrophoretic apparatus further comprises a buffer waste vial air-tightly connecting said running end to a vacuum source, such that excess buffer may be sucked into and retained by said sample waste vial.

8. An electrophoretic apparatus according to claim 2 wherein said electrophoretic channels each has a loading end and a running end, said sample reservoirs and buffer reservoirs connected to said loading end; said electrophoretic apparatus further comprises a buffer waste vial air-tightly connecting said running end to a vacuum source, such that excess buffer may be sucked into and retained by said sample waste vial.

9. An electrophoretic apparatus according to claim 1 wherein said sample reservoir includes a sample inlet reservoir with a sample inlet end and a sample outlet reservoir with a sample outlet end, said sample loading module connected to said sample inlet end, said electrophoretic apparatus further comprises a sample disposal module, connected to said sample outlet end, for draining excess sample from said sample reservoir.

10. An electrophoretic apparatus according to claim 2 wherein said sample reservoir includes a sample inlet end and a sample outlet end, said sample loading module connected to said sample inlet end, said electrophoretic apparatus further comprises a sample disposal module, connected to said sample outlet end, for draining excess sample from said sample reservoir.

11. An electrophoretic apparatus according to claim 1 wherein said sample reservoir includes a sample inlet end and a sample outlet end, said sample loading module connected to said sample inlet end; said electrophoretic apparatus further comprises a sample disposal module having a sample waste vial air-tightly connecting said sample outlet end to a vacuum source, such that excess sample may be sucked into and retained by said sample waste vial.

12. An electrophoretic apparatus according to claim 2 wherein said sample reservoir includes a sample inlet end and a sample outlet end, said loading module connected to said sample inlet end; said electrophoretic apparatus further comprises a sample disposal

module having a sample waste vial air-tightly connecting said sample outlet end to a vacuum source, such that excess sample may be sucked into and retained by said sample waste vial.

13. An electrophoretic apparatus according to claim 1 wherein said power source is further electrically connected to said sample channels for supplying an electrical voltage between said sample reservoir, said buffer reservoir and said electrophoretic channel.

14. An electrophoretic apparatus according to claim 1 wherein said vial holding means is a rack.

15. An electrophoretic apparatus according to claim 2 wherein said pneumatic means further comprises a tubing and valve system for controlling the level of fluid pressure reaching said vial.

16. An electrophoretic apparatus according to claim 4 wherein said pneumatic means further includes a tubing and valve system for controlling the level of fluid pressure reaching the sample vial; and said buffer pneumatic means includes a tubing and valve system for controlling the level of fluid pressure reaching the buffer container.

17. An electrophoretic apparatus according to claim 4 wherein said pneumatic system further comprises a tubing and valve system having a first valve for controlling the fluid pressure reaching the sample vials, and a second valve for releasing residual pressure after sample loading is complete.

18. An electrophoretic apparatus according to claim 4 wherein said buffer pneumatic system further comprises a tubing and valve system having a first valve for controlling the fluid pressure reaching the buffer container, and a second valve for releasing residual pressure after buffer loading is complete.

19. A loading system for dispensing liquid from at least one container into a plurality of receptacles comprising :

a sample loading module having

a fluid pressure source;

vial holding means adapted to receive a plurality of sample vials containing samples in an air-tight manner;

connecting means for separately connecting each of said receptacle to the sample in a corresponding sample vial; and

pneumatic means for air-tightly connecting said sample in said sample vials to said fluid pressure source, said pneumatic means having interconnecting conduits for forcing said samples into a corresponding receptacle.

20. A loading system according to claim 19 further comprising

a liquid loading module having :

liquid holding means adapted to receive at least one liquid container in an air-tight manner;

liquid connecting means for connecting each of said receptacle to the liquid in said liquid container; and

liquid pneumatic means for air-tightly connecting said liquid container to said fluid pressure source, said liquid pneumatic means having a second set of interconnecting conduits, for forcing said liquid into a corresponding receptacle.

21. A loading system according to claim 19 wherein said receptacle is an electrophoretic channel, a column or a well.

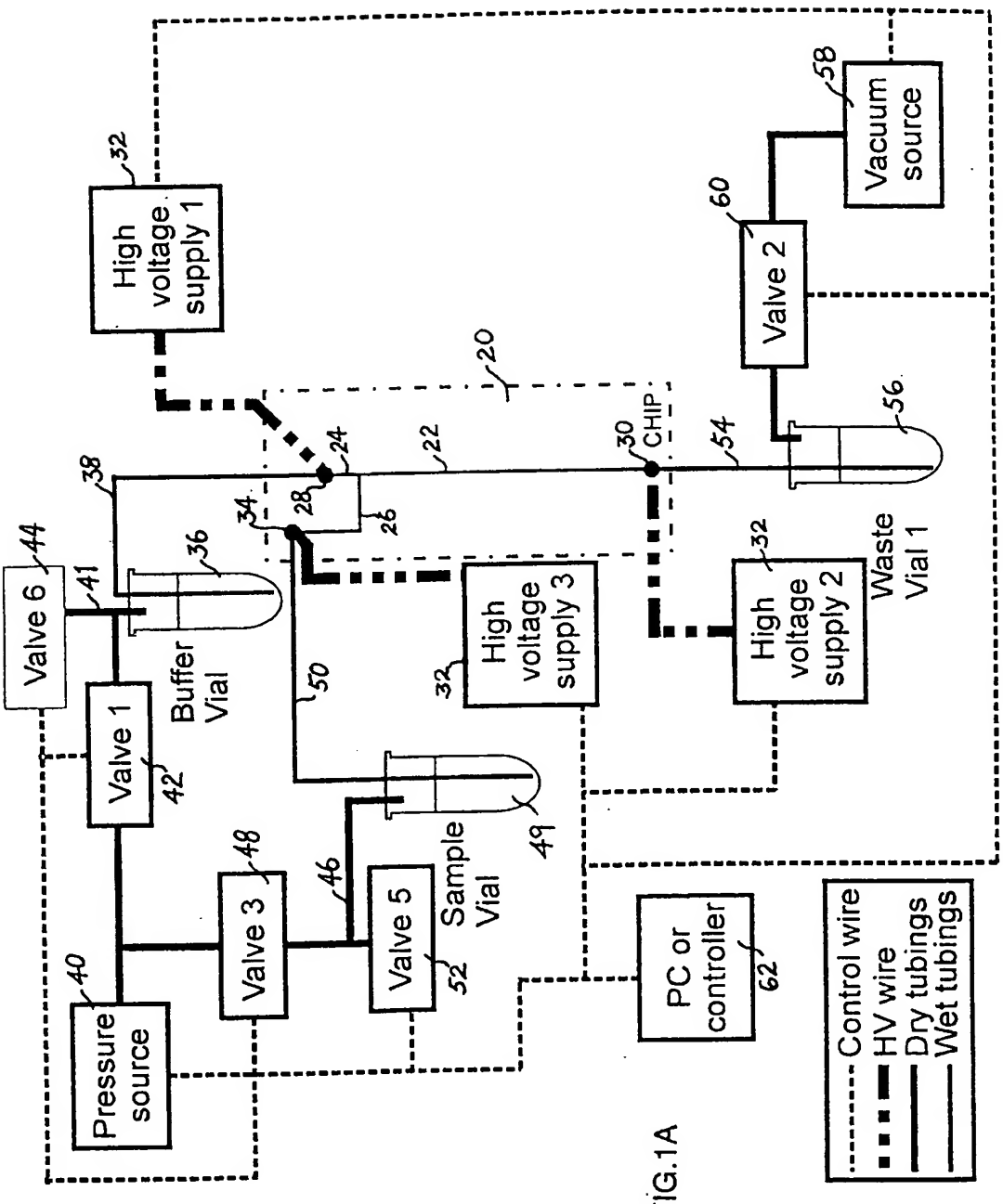
High voltage supply 1
32
Vacuum source
58
Valve 2
60
20
CHIP
30
22
24
38
34
28
26
54
56
Valve 6
44
41
36
Buffer Vial
50
High voltage supply 3
32
High voltage supply 2
32
Waste Vial 1
Valve 1
42
Sample Vial
49
Valve 3
48
46
Valve 5
52
Pressure source
40
PC or controller
62
Control wire
HV wire
Dry tubings
Wet tubings

FIG.1A

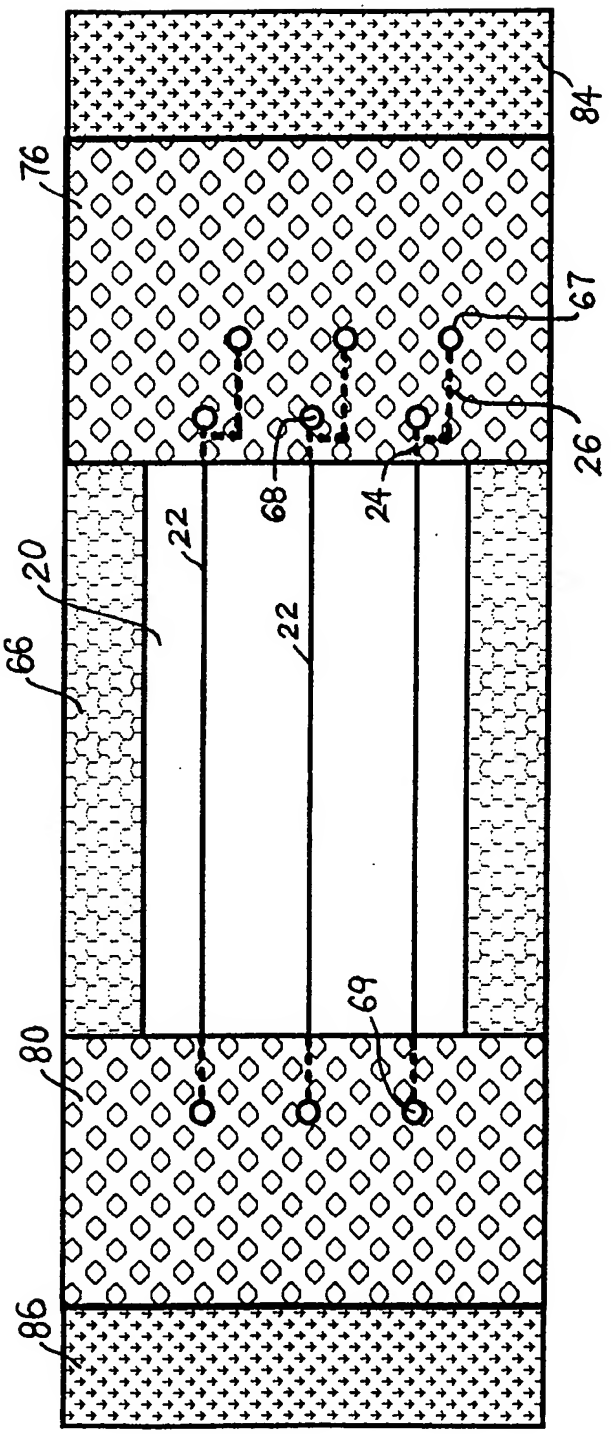

FIG.1B

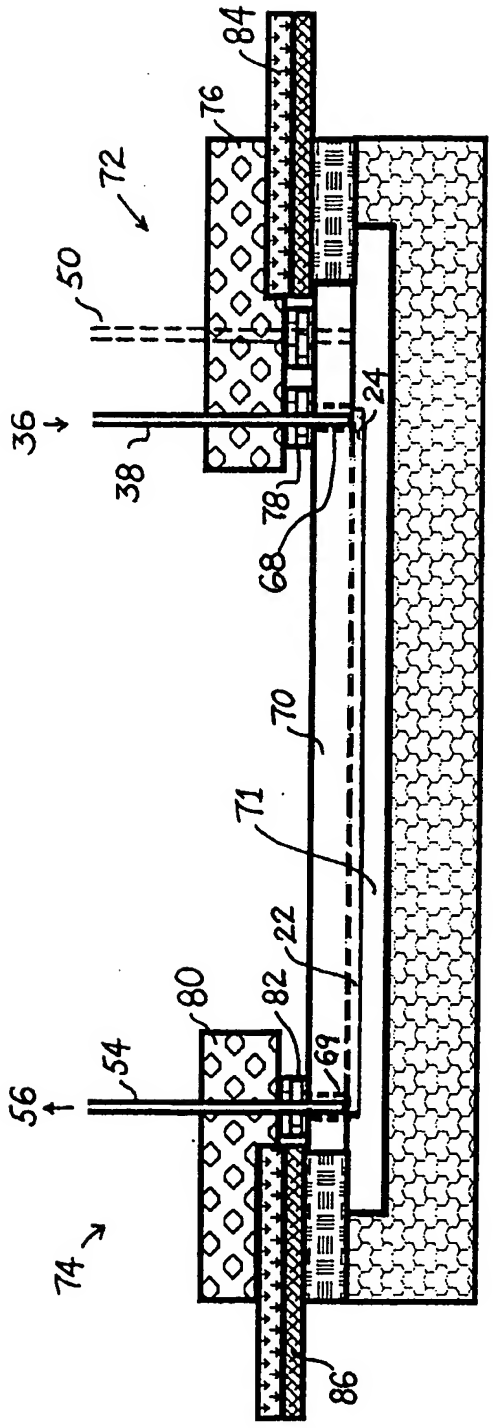

FIG.1C

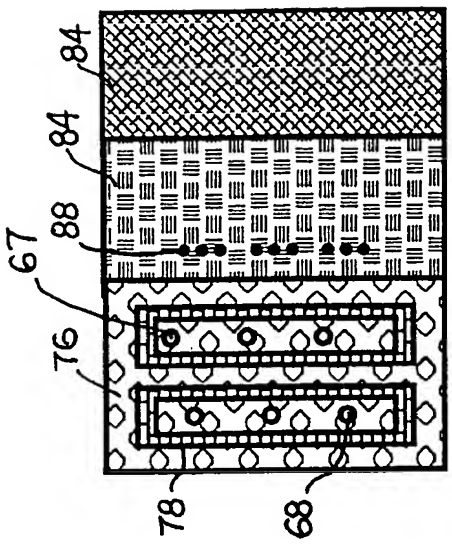

FIG.1D

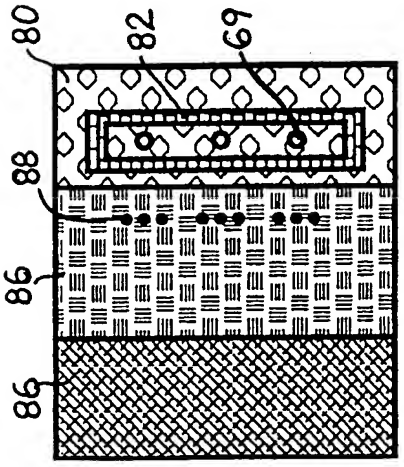

FIG.1E

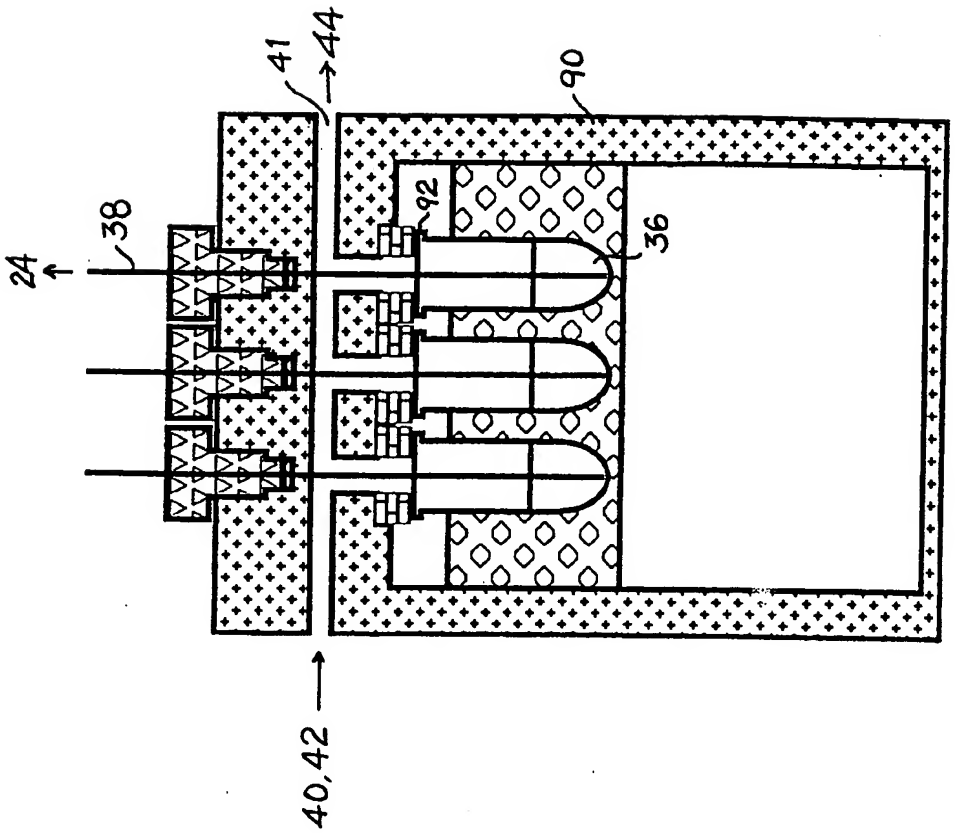

FIG.1F

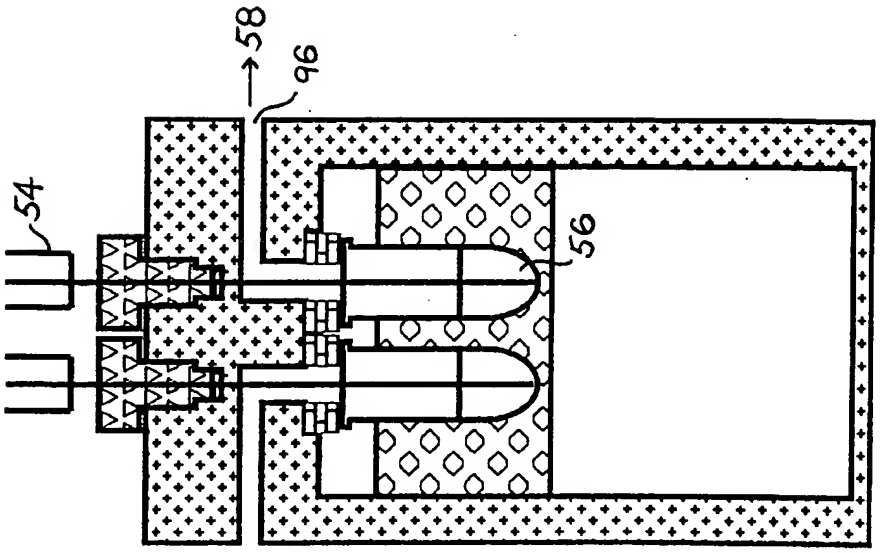

FIG1G

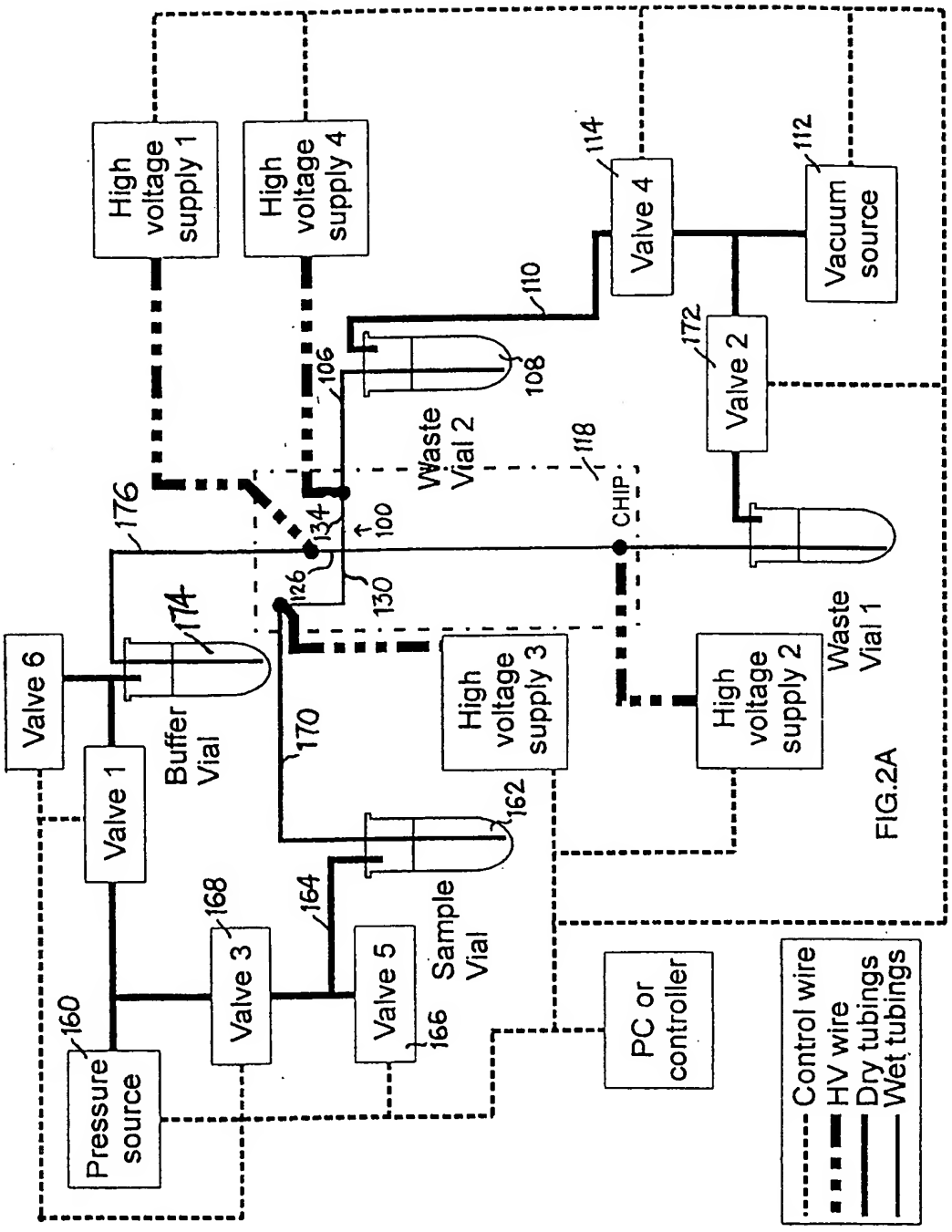
High voltage supply 1
High voltage supply 4
Valve 4
Vacuum source
Valve 2
Waste Vial 2
CHIP
Valve 6
Valve 1
Buffer Vial
High voltage supply 3
High voltage supply 2
Waste Vial 1
Valve 3
Valve 5
Sample Vial
Pressure source
PC or controller
Control wire
HV wire
Dry tubings
Wet tubings
100
106
108
110
112
114
118
126
130
134
160
162
164
166
168
170
172
174
176

FIG.2A

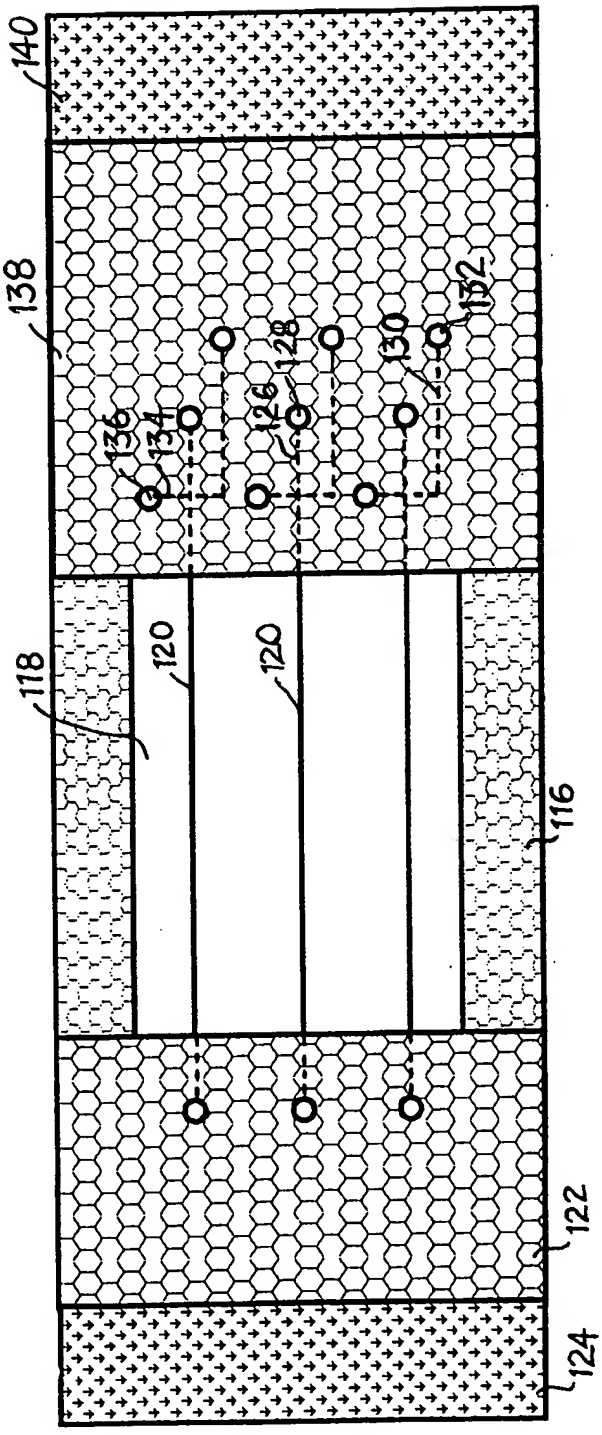

FIG.2B

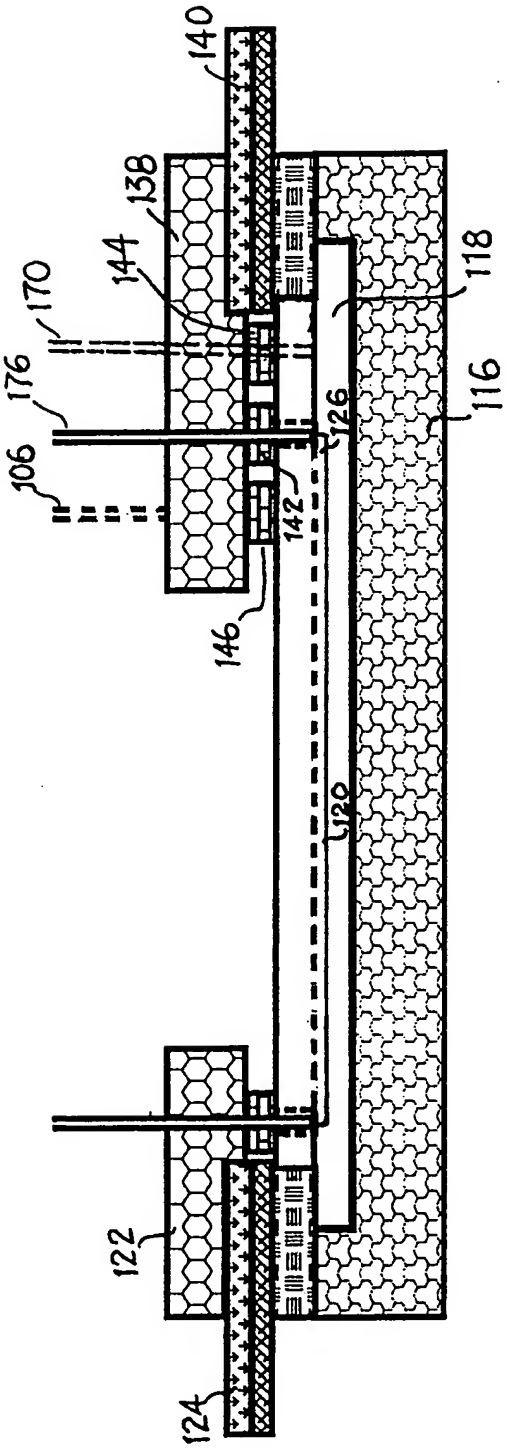

FIG.2C

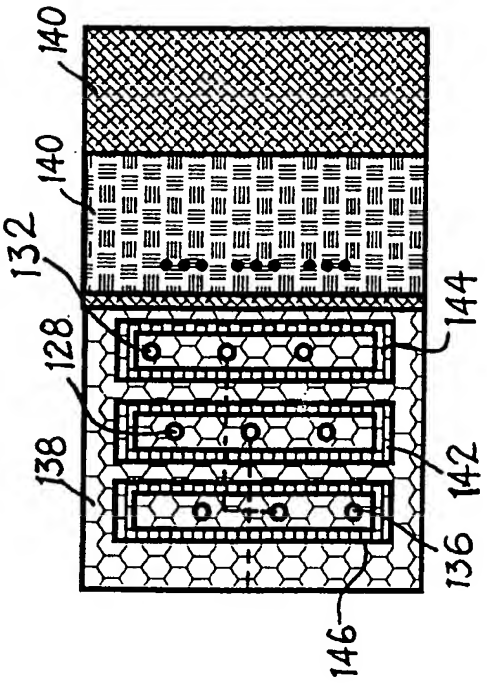

FIG.2D

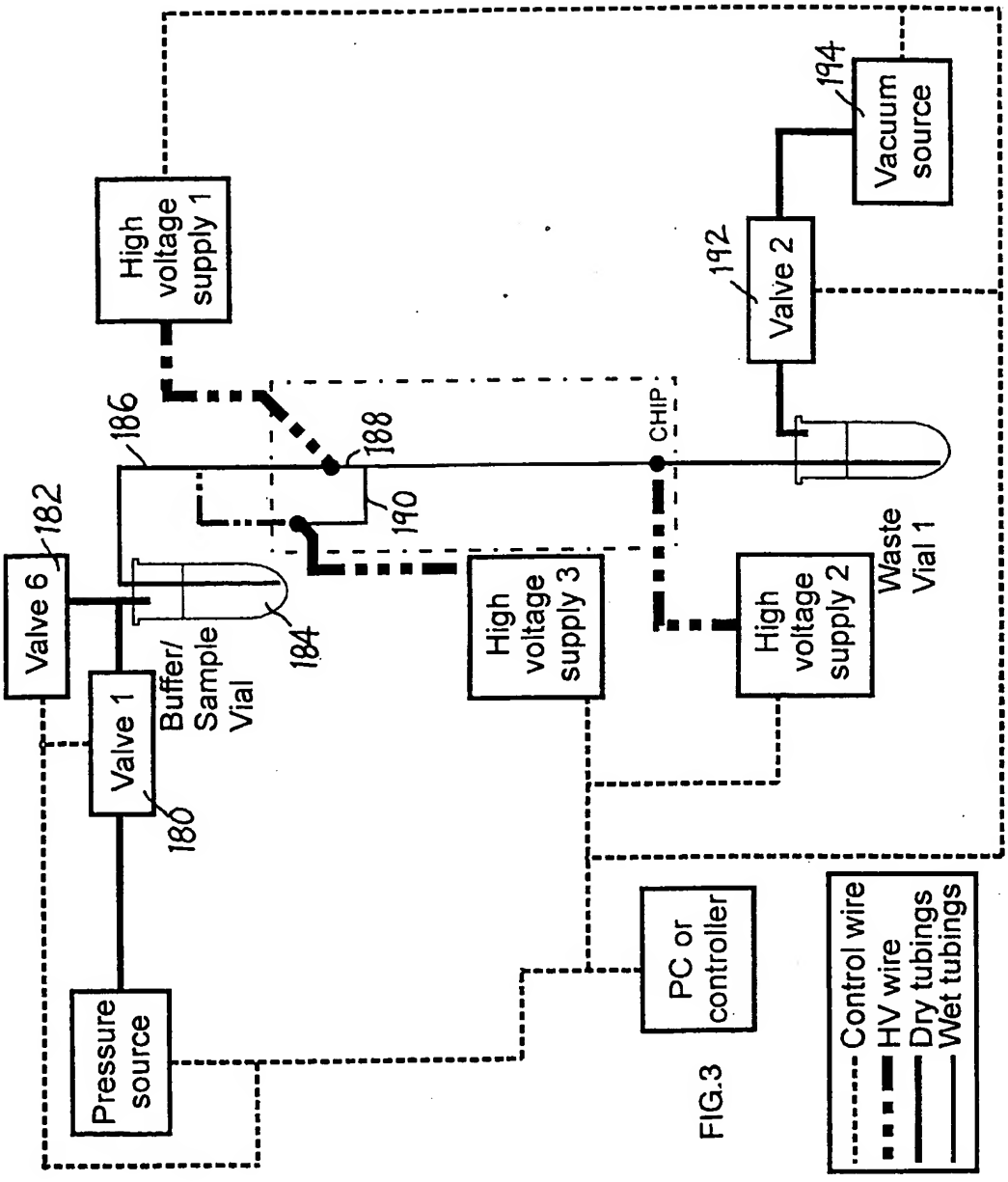
High voltage supply 1
Vacuum source
194
Valve 2
192
186
188
CHIP
190
182
Valve 6
184
Buffer/ Sample Vial
High voltage supply 3
High voltage supply 2
Waste Vial 1
Valve 1
180
Pressure source
PC or controller
Control wire
HV wire
Dry tubings
Wet tubings

FIG.3

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SG 00/00033

CLASSIFICATION OF SUBJECT MATTER

IPC[7]: G01N 27/447; G01N 33/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC[7]: G01N

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

WPI Database, Derwent Publications Ltd., London (GB)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
P,A	WO 00/05435 A2 (CE RESOURCES PTD LTD.), 1 February 2000 (01.02.00) totality	1-21
A	WO 98/09161 A1 (THE REGENTS OF THE UNIVERSITY OF CALIFORNIA), 5 March 1998 (05.03.98) totality	1-21

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:
„A" document defining the general state of the art which is not considered to be of particular relevance
„E" earlier application or patent but published on or after the international filing date
„L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
„O" document referring to an oral disclosure, use, exhibition or other means
„P" document published prior to the international filing date but later than the priority date claimed

„T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
„X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
„Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
„&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
24 May 2000 (24.05.2000)	11 August 2000 (11.08.2000)

Name and mailing adress of the ISA/AT	Authorized officer
Austrian Patent Office Kohlmarkt 8-10; A-1014 Vienna Facsimile No. 1/53424/535	Weniger Telephone No. 1/53424/341

Form PCT/ISA/210 (second sheet) (July 1998)

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
PCT/SG 00/00033

Patent document cited in search report			Publication date	Patent family member(s)			Publication date
WO	A2	00005435	03-02-2000	AU	A1	53115/99	14-02-2000
WO	A3	00005435	27-04-2000				
WO	A1	9809161	05-03-1998	AU	A1	40905/97	19-03-1998
				AU	B2	714163	23-12-1999
				CN	A	1235674	17-11-1999
				EP	A1	922218	16-06-1999
				US	A	5906723	25-05-1999
				US	A	6045676	04-04-2000